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(54) Title of Invention: Secondary Air Supplier for Engine	(72) Inventor: Shinichi Wakutani c/o Mazda Corp 3-1 Shinchi, Fuchu, Aki County, Hiroshima Prefecture
(21) Patent application S62·8431	(72) Inventor: Hidetaka Chikasue c/o Mazda Corp 3-1 Shinchi, Fuchu, Aki County, Hiroshima Prefecture
(22) Application date: January 16, 1987	(71) Applicant: Mazda Corp. 3-1 Shinchi, Fuchu, Aki County, Hiroshima Prefecture
(72) Inventor: Yoshinori Okino c/o Mazda Corp 3-1 Shinchi, Fuchu, Aki County, Hiroshima Prefecture	(74) Agent: Etsuji Kotani, a patent attorney and two others

Specification

1. Title of Invention

Secondary Air Supplier for Engine

2. Scope of Claims

1. A secondary air supplier for an engine, of a type of a secondary air supplier for an engine wherein the supply of air to the exhaust passage is controlled depending on driving conditions of the engine, comprising:
two air pumps for the secondary air supply with at least one of the air pumps made to be a small air flow air pump matching the demanded air flow volume in the driving range where the demanded secondary air flow amount is small,
a secondary air supplier control means for switching the secondary air supply between

a state in which secondary air is supplied from the small air flow pump in a state in which secondary air flow is supplied from the other air pump or from both air pumps depending on the driving condition, and
a switching point alteration means for changing the switching point of the secondary air supply by the secondary air supply control means to and from the normal driving time and transition time.

3. Detailed Description of Invention

(Field of Application)

The present invention relates to a secondary air supplier of an engine that controls the secondary air supply to the exhaust passage.

(Prior Art)

Heretofore, various secondary air suppliers for an engine which contribute to the exhaust cleaning function by supplying secondary air to the exhaust passage have been known. In fact, in an engine with a natural air suction passage and a super charge passage in which a super charger is installed, an engine wherein the super charger is made to function also as air pump for secondary air supply by connecting a secondary air flow passage branched off from a super charge passage at the bottom the super charger to the exhaust passage is already known (See Japan Laid Open Patent Publication S58-51221). Also there are engines wherein the electric power air pump is provided as an exclusive secondary air supplier.

In an engine in which the super charger is also used as an air pump for secondary air supply, the super charger is always driven during the driving state demanding secondary air supply even if the engine is in a transition state. In particular, even if in a driving state demanding only a small amount of secondary air, the super charger with an unnecessarily larger pumping capacity compared to demanded secondary air amount is driven, imposing relatively heavy load on the engine and waste in fuel cost. Moreover, in an engine in which exclusive secondary air pump is provided, sufficient fuel cost improvement is not achieved because the air pump needs to be large enough to meet the maximum amount of secondary air required in order to supply secondary air over the entire secondary air supply domain with only one pump.

(Purpose of Invention)

Considering the background described above, the present invention basically aims to reduce the fuel cost of an engine by providing switching control in which a small air pump is used in the driving state with a small secondary air amount required and another air pump or two air pumps are used in the driving state with not enough secondary air being supplied. In this manner, the proper secondary air amount matching the driving state is always supplied, and the load imposed by the air pumps is eased, resulting in improved fuel savings.

Moreover, if the secondary air supply is switched using two air pumps as described above, there is the problem that the optimum secondary air supply may not be possible because the universal setting of the switch point to meet the demand of normal driving time ignores the differences in temperature, air/fuel ratio and other conditions of the exhaust system at the switching point during transition time such as the deceleration period from those of normal driving time. With a focus on such problem as well, the present invention also aims at enabling the optimum secondary air supply for both the normal driving state and the transition state.

(Construction of Invention)

The secondary air supplier for an engine of the present invention is of a type of a secondary air supplier for an engine wherein the supply of air to the exhaust passage is controlled depending upon the driving conditions of the engine, and comprises two air pumps for secondary air supply with at least one of the air pumps made to be a small air flow air pump matching the demanded air flow amount in the driving range where the demanded secondary air flow amount is small, a secondary air supplier control means for switching the secondary air supply between a state in which secondary air is supplied from the small air flow pump and a state in which the secondary air flow is supplied from the other air pump or from both air pumps depending on driving conditions, and a switching point alteration means for changing the switching point of the secondary air supply by the secondary air supply control means to and from the normal driving time and transition time.

With such construction, the present invention enables the use of two air pumps depending on the required amount of secondary air flow. Moreover, adjustment of secondary air supply is executed depending on the differences of temperature and other conditions of the exhaust systems at the time of normal or transition driving.

(Embodiment)

Fig. 1 illustrates the structure of the supplier in an embodiment of the present invention. Engine 1 in the figure is a rotary piston engine comprising a casing 2 with a pre-determined shape, and a rotor 3 that moves in a planetary rotation motion within the casing. Operation chamber 4 is provided in casing 2. In casing 2 of engine 1 are formed a main suction port 5 that opens to operation chamber 4 during the suction process, a super charge port 6 that closes following the closure of the main suction port 5, and an exhaust port 7 that opens to operation chamber 4 during the exhaust process. Ports 5, 6, 7 are connected respectively to main suction passage 8, super charge passage 9 and exhaust passage 10.

The upper flow side edge of the main suction air passage 8 is connected to air cleaner 11. In the main suction air passage 8 are arranged, in order from upper flow side, an air flow meter 12 for detecting the suction air amount, a throttle valve 13, and a fuel injection valve 14. Meanwhile, the upper flow side edge of the super charge passage 9 is connected to the main suction air passage at the bottom of the air flow meter 12. In the super charge passage 9 is provided a super charge pump 15 functioning as a super charger and a secondary air pump supply air pump. The super charge pump 15 is connected to the output shaft (unrepresented) of engine 1 through an electromagnetic clutch 16. In the super charge passage 9 are provided super charge control valve 17 which is controlled by signals from the control unit 31, to be explained later, to open in the driving range above pre-determined load, and rotary valve 18 that controls the timing for the super charged air supply to engine 1. Secondary air passage 21 branches off from super charge passage 9 between upstream of the super charge control valve 17 but downstream from super charge pump 15. In the passage 21, the secondary air control valve (hereafter referred to as "super charge pump side ACV") 22 and air flow meter 23 for detecting secondary air flow amount are provided. The bottom flow edge of secondary air passage 21 is connected to exhaust air passage 10 in the vicinity of exhaust port 7 in such a manner that port air is supplied upstream of the exhaust air cleaning equipment such as a catalyst converter which is

provided in exhaust air passage 10. Moreover, in super charge passage 9, relief passage 25 connecting the downstream and upstream of super charge pump 15 is formed, a relief control valve 26 also being installed in passage 25.

Separate from secondary air passage 21 that branches off from the super charge passage 9, a secondary air passage 27 with upstream side edge connected to air cleaner 11 is formed. Moreover, a small electric power air pump (small amount air pump) 28 to be driven by a motor (unrepresented) through an electromagnetic clutch 27 is provided in the secondary air passage 27. A secondary air control valve (hereafter, referred to as "electric power air pump side ACV") 30 is installed downstream of the electric power air pump 28 in the secondary air passage 27. Moreover, passage 27a, passage 27b and passage 27c are also formed downstream, respectively for port air supply upstream of exhaust cleaner 24, for splitting the air supply to the middle section of exhaust air cleaner 24, and for relief upstream of air cleaner 11.

Furthermore, "31" denotes a control unit consisting of micro computer and the like. Detection signals from air flow meters 12, 23, detection signals from rotation number sensor 32 that detects the number of engine rotations and detection signals from throttle opening sensor 33 that detects the opening of throttle valve 13 and others are entered in the control unit 31. Control unit 31 outputs signals respectively controlling clutch 16 of super charge pump 15, the super charge pump side AVC and the super charge control valve 17, and signals that control fuel injection valve 14, relief control valve 26 and others.

Aforementioned control unit 31 contains a secondary air supply control means 34 that switches secondary air supply between state wherein aforementioned electric power air pump 28 supplies secondary air depending on driving condition in addition to supplying secondary air in the specific driving domain and state wherein super charge pump 15 supplies secondary air, and switch point alteration means 35 that changes the secondary air supply switching point depending on the normal period and the super charge period of the engine.

The super charge domain, secondary supply domain from each pump, and others are pre-established in control unit 31 as illustrated in Fig. 2. In fact, a driving domain in which throttle opening (engine load) is larger than a pre-determined value is defined as a super charge domain. At the same time, for secondary air supply during a

non-super charge period, the side with a lower load than the pre-determined line DC1 (shaded area) is defined as the port air supply domain. In the port air supply domain, the domain in which the number of rotation is smaller than pre-determined rotation number R0 where the electric power air pump 28 is able to supply secondary air demand amount during normal driving is defined as the electric power pump port air supply domain Pa, and the domain where rotation is higher than a pre-determined rotation number R0 is defined as the super charge pump port air supply domain Pb. In the present embodiment, the secondary air supply by each pump is switched at aforementioned pre-determined rotation number R0, and the switching point is shifted during the deceleration time in which delay time is provided in switching. Here, DC2 indicates a fuel cut line during deceleration, and the fuel supply is stopped on the side where the load is lower than line DC2.

Fig. 3 is a flowchart describing a concrete example of control executed by aforementioned control unit 31. In the flowchart, first, suction flow amount Q1 detected by air flow meter 12, engine rotation number RPM and throttle opening TVO are read in step S1. Next, in step S2, the pulse width τ of the injection pulse for fuel injection valve 14 based on suction flow amount per engine rotation is computed. Then in step S3, the driving state obtained by the engine rotation number and the throttle opening at the time is checked to see if it is on the side where the load is smaller than line DC1 in Fig. 2.

If the result of determination in step S3 is NO, a determination is made as to whether or not the driving state is in the super charge domain (step S4). If the driving state is in the super charge domain, clutch 16 of super charge pump 15 is turned ON (step S5), otherwise clutch 16 is turned OFF. Moreover, in either state, the super charge pump side ACV is closed (step S7), and in step S8, the fuel is injected with the pulse width from fuel injection valve 14.

If the result of determination in step S3 is YES (the driving state is in the port air domain), a check is made in step S9 as to whether or not engine rotation number RPM is below a pre-determined rotation number R0. If the result of determination in step S9 is NO, clutch 16 of super charge pump 15 is turned ON, at the same time, the super charge pump side ACV 22 is opened (step S10, S11), through which super charge pump 15 executes a secondary air supply, and clutch 29 of electric power air pump 28 is turned OFF (step S12). In this case, the secondary air flow amount Q2 detected by air

flow meter 23 is read, and the injection pulse width τ is modified based on the value obtained by subtracting the secondary air flow volume Q2 from the suction air flow volume Q1 (step S13, S14).

Next, in step S15, a determination is made as to whether or not the load is lower than fuel cut line DC2. If the result of determination is YES, the process moves back to step S8, but if it is NO, a fuel cut is executed (step S16).

If the engine rotation number RPM is determined to be pre-determined rotation number R0 or less at aforementioned step S9, delay time A corresponding to a level of deceleration which is checked by the change in the engine rotation number is set for timer TM (step S19, S20) immediately after the engine rotation number falls below pre-determined rotation number based on the determination of whether or not the engine rotation number of the previous time was larger than a pre-determined rotation number S0 (step S0). Subsequently, the timer TM is decremented until it becomes 0 (step S19, S20). Aforementioned delay time A is set to be virtually 0 when the level of deceleration is sufficiently small, but is set to be a larger value with the level of deceleration.

When aforementioned timer becomes 0, in other words when the delay time A elapses, clutch 29 of electric power air pump 28 is turned ON, at the same time, electric air pump side ACV 30 is opened (step S21, S22). Moreover, clutch 16 of super charge pump 15 is turned OFF and super charge pump side ACV 22 is closed (step S23, S24). In this manner, secondary air supply by electric power air pump 28 is executed. Then, a determination is made in step S15 and the processes of step S8 or step S10 corresponding to the determination of step S15 are executed.

In the system described above, within the domain where engine rotation is less than or equal to pre-determined rotation number R0 with relatively small secondary air demand amount in the secondary air supply domain, secondary air is supplied to exhaust passage 10 by a small electric power air pump 28. Hence, the load for driving the pump is less than when super charge pump 15 is driven. On the other hand, in the driving domain where engine rotation is higher than a pre-determined rotation number R0 and where secondary air is insufficient with the electric power pump 28 due to a large amount of demand for secondary air, secondary air is supplied by super charge pump 15, as a result, sufficient secondary air amount is supplied.

When the driving condition shifts from the domain where secondary air supply is supplied by super charge pump 15 to the domain where secondary air is supplied by electric power air pump 28, and during mild driving condition shift close to a normal driving condition, the secondary air supply amount is adjusted to satisfy the secondary air demand amount of normal driving time through switching from the super charge pump driving condition to the electric power air pump driving condition at the time when the engine rotation reaches a pre-determined rotation number R0, as illustrated in Fig. 4(a). Moreover, during the deceleration period with a rapid engine rotation drop, switching is delayed for the time corresponding to the level of deceleration, through which the rise in the temperature of the exhaust cleaner 24 is controlled. In other words, in the condition in which the pump is shifted from the super charge pump 15 to the electric power air pump 28, secondary air that has been supplied in a relatively large amount up to that point decreases and the cooling function of the secondary air weakens, causing the temperature of the exhaust cleaner 24 to rise. In particular, during rapid deceleration from high rotation, namely high load condition, the temperature of exhaust cleaner 24 is already high and fuel attached to the wall surface of main suction passage 8 is large, hence the temperature rise becomes noticeable if the switching point is the same as the normal driving condition as described by broken lines in Fig. 4(b). On the other hand, when switching is delayed as in aforementioned case, a relatively large amount of secondary air is supplied from the super charge pump during delay, and the temperature rise of exhaust cleaner 24 is controlled, indicated by real lines in Fig. 4(b).

In the embodiment above, electric power air pump 28 is used as a small flow amount air pump and super charge pump 15 is made to function also as another secondary air supply air pump, but the small flow amount air pump is not limited to an electric power air pump, and an engine driven mechanical pump and the like may be used as long as it is small. Moreover, the other air pump is not limited to a super charger, but a pump exclusively for secondary air supply may be used. As far as the separate usage of two air pumps are concerned, only one pump may be used to supply secondary air in the domain where secondary air demand amount is small, and secondary air may be supplied by both pumps in the domain with a large secondary air demand amount, in which case, relatively small pumps may be used for both pumps.

(Efficacy)

As illustrated above, the present invention provides two air pumps for secondary air supply to the exhaust passage, at least one of which is a small flow amount air pump, and adopts switching control between the condition in which secondary air is supplied from the small flow amount air pump and the condition in which secondary air is supplied from the other air pump or both air pumps depending on the driving conditions. Hence, the load on air pump is reduced in the driving domain with small secondary air demand amount while sufficiently supplying the secondary air demand amount corresponding to the driving condition, enabling improved fuel savings. In addition, the present invention changes secondary air supply switching point corresponding to the normal driving state and the super charge state. Hence, the secondary air supply amount may be adjusted properly with differences in temperature, air/fuel ratio and other conditions during normal driving state and super charge state.

4.Brief Description of Drawing

Fig. 1 is an overall schematic diagram illustrating the embodiment of the present invention.

Fig. 2 is an illustration describing domain in which secondary air is supplied from each pump, super charge domain, and others.

Fig. 3 is a control flow chart.

Fig. 4(a) (b) are illustrations describing switching of secondary air supply and change in secondary air supply amount and change in exhaust temperature during normal driving state and deceleration state.

1.Engine, 15. Super charge pump functions also as exclusive secondary air supply air pump. 28. Electric power air pump (small air flow amount pump) 21, 27. Secondary air passage 22, 30. Secondary air control valve 31. Control unit 34. Secondary air supply control means 35. Switching point alteration means

Patent applicant: Mazda Corp.

Agent: Etsuji Kotani, patent attorney

Tadashi Nagata, patent attorney

Yasuo Itaya, patent attorney

Fig. 1 34. Secondary air supply control means

35. Switching alteration means

Fig. 2

Throttle opening level Super charge domain Engine rotation number

Fig. 3

S1: Read suction air flow amount Q1, engine rotation number RPM, and throttle opening level TVD

S2: Compute injection pulse width τ

S3: Below DCI?

S4: Super charge domain?

S5: Super supply pump clutch ON

S6: Super charge pump clutch OFF

S7: Super charge pump side ACV closed

S8: Inject fuel with pulse width τ

S10: Super charge pump clutch ON

S11: Super charge pump side ACV open

S12: Electric power air pump OFF

S13: Read secondary air flow amount Q2

S14: Modify injection pulse width τ by computing (Q1-Q2)

S15: Above DC2?

S17: Was previous time large than R0?

S18: Set delay time corresponding to deceleration level TM-A

S21: Electric power air pump clutch ON

S22: Electric power air pump side ACV open

S23: Super charge pump clutch OFF

S24: Super charge pump side ACV closed

Fig 4 (a)

Exhaust cleaner temperature

Secondary air amount supply by super charge pump

Secondary air amount supply by electric power pump

Time

(b)

Exhaust cleaner temperature

Secondary air amount supply by super charge pump

Secondary air amount supply by electric power pump

Time